

TIN & TANTALUM



Sn
Ta



Cassiterite

FORMATION & LOCATION

- Both tin and tantalum exist in the Earth's crust in low concentrations of about two parts per million (ppm).
- Because of the price and demand for each metal, tantalum must be concentrated under normal conditions at least 250-300 times to form a viable deposit, whereas tin needs to be concentrated about 5,000 times (gold must be concentrated 2,000-10,000 times).
- Cassiterite (SnO_2) is by far the most important mineral ore of the metal tin. It occurs as dark red-brown crystals up to 10mm in size.

- Tantalum is found in tantalite concentrate (Ta_2O_5) and occurs in the mineral ores:
 - Tantalite ($(\text{Fe},\text{Mn})(\text{Nb},\text{Ta})_2\text{O}_6$; 60% Ta_2O_5),
 - Wodginite ($\text{Mn}_4(\text{Sn},\text{Ta})_4\text{Ta}_6\text{O}_{32}$; 60-74% Ta_2O_5),
 - Microlite ($\text{Ca}_2\text{Ta}_2\text{O}_7$; 80% Ta_2O_5) and
 - Manganotantalite (MnTa_2O_6 , 80% Ta_2O_5).

Most tantalum bearing minerals are less than 0.5mm in size and are either separate grains or contained within other minerals, such as cassiterite.

- In Western Australia, tin and tantalum minerals are found in pegmatite lenses that lie within or next to ancient greenstone belts. The original greenstone belts formed during Archaean volcanic activity over 2,500 million years ago. Volcanic sediments were later intruded with Archaean granite batholiths (large plumes of molten granite rising from beneath the Earth's crust) that caused deformation and metamorphism in the surrounding rocks. The intruding granite magmas carried rich fluids that deposited tin and tantalum minerals in pegmatites during this process. These original deposits are called primary deposits.
- Secondary deposits (placers) formed from the weathering and erosion of primary tin and tantalum deposits. Cassiterite does not break down easily and can be moved and concentrated by erosion processes. These concentrations may develop over a primary deposit (eluvial) and on slopes below the deposit (colluvial). When the cassiterite reaches a drainage system, it may be transported to a river channel and concentrated into an alluvial placer deposit.
- Tantalum deposits are very rare, however, Western Australia has two operating mines, one at Greenbushes about 250km south of Perth and another at Wodgina in the Pilbara, south of Port Hedland. These are the two largest tantalum mines in the world. In Western Australia tin is only processed as a by-product of tantalum mining.



c.3500 BC

Tin used in bronze in ancient Iraq. The ancient Egyptians and Babylonians were familiar with tin and used it in combination with copper to make bronze.

1500 BC

Earliest tin mining and production in Persia.

100 AD

Copper was first coated with tin.

1700

Tin plated iron was manufactured.

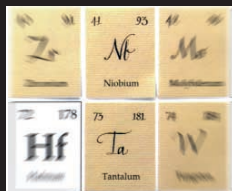
MINING

- Placer deposits can be worked by simply using bucket dredges or front-end loaders to dig and load the ore onto dump trucks for transport to the mill for processing. With abundant water present, gravel pumping could be used as an alternative, whereby the alluvium is broken up by a high pressure jet of water and the resulting slurry is pumped straight to the concentrating plant.
- Prior to 1970, production from Greenbushes came from alluvial deposits surrounding the primary deposit and used simple gravity methods for processing. Lateritic caprock and a major highway along its length masked the extent of the primary deposit. In the early 1970's, faced with dwindling alluvial reserves, the miners turned to the weathered pegmatite ore to continue production, and only then realised the large size of the deposit.
- Most placer deposits in Western Australia are now exhausted, and mining is focussed upon the weathered and unweathered primary orebodies nearby.
- Today, both Greenbushes and Wodgina are open cut operations. Initially, mining in the weathered zone was relatively easy with front-end loaders digging out the soft mineralised rock as well as waste rock and loading into large dump trucks for transfer to the mill for crushing and processing.
- As mining progressed through the weathered zone into fresh rock, drill blasting became necessary. Specially designed drill rigs sink holes in and around the rich ore zone, which are then packed with explosives and detonated. When safe, front-end loaders and dump trucks move in and begin loading and transferring the ore to the mill and the waste rock to waste dumps.
- With the pit expansion, topsoil is removed and stockpiled for later use, or spread over contoured waste dumps for immediate rehabilitation.



1802

Tantalum first discovered by Andreas Gustav Ekberg in Europe, although many chemists thought that tantalum and niobium were identical elements.



1844

Heinrich Rose isolated tantalum from niobium.



1888

Alluvial cassiterite discovered at Greenbushes.



1903

The first relatively pure tantalum metal was produced by von Bolton.



1905

Invention of the tantalum filament for electric lights creates world market for the metal. Production began near Wodgina making WA the world's major producer for several years.



1920 - 1955

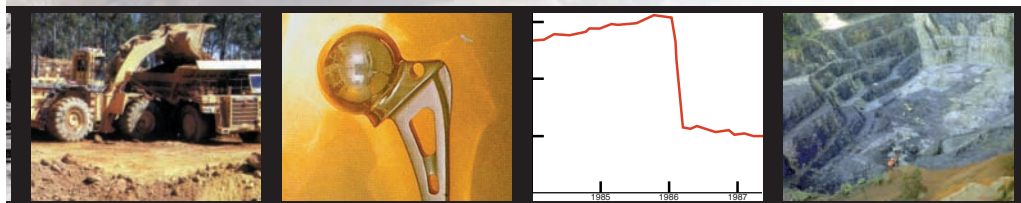
Due to high world supply and low price, tin output declined across Australia.

PROCESSING

- The Wodgina and Greenbushes processing plants produce tantalite concentrate and cassiterite concentrate from mined ore by gravity separation mechanical methods, with no added chemicals involved.
- The ore is crushed to less than 10mm with a jaw and cone crusher, then mixed with water and further ground to less than 0.5mm in ball mills (large rotating rubber-lined tumblers containing steel balls). The finely ground ore is passed through a series of cyclones, spiral concentrators and gravity tables that separate the ore minerals into a primary concentrate from the lighter tailings such as quartz. A 'cyclone' is essentially a large cone with openings at the top and base. Crushed ore is fed in with air or as a slurry with water and separated as heavier material sinks to the base and lighter material is collected near the top. A 'spiral concentrator' has ridges in a spiral pattern on the inside to make the process more efficient. A 'gravity table' separates ore by weight (and viscosity if in a slurry) by simply shaking the ore across a contoured surface, dividing the heavier components from the lighter ones. The concentrate is pumped to the next phase whilst the tailings are then discharged into waste dumps.
- The primary concentrates are filtered and dried. Electromagnetic and electrostatic separation methods are used to separate the cassiterite concentrate from the tantalite concentrate and remove heavy mineral impurities such as ilmenite, garnet and tourmaline.
- The tantalite concentrate containing about 33% tantalum is packed into metal drums and transported to Perth for export. The cassiterite concentrate contains about 70% tin and small amounts of tantalum that is transferred to furnaces for smelting.
- Cassiterite is reduced to tin by heating with carbon at 1,200°C to 1,300°C. Electric furnaces are used to smelt tin concentrate and to re-smelt slag (the waste left after the ore has been smelted) for additional tantalum recovery. A furnace charge consists of cassiterite, a carbon reducing agent (charcoal or coke), and limestone and silica fluxes. Smelting in the primary furnace takes 10 to 12 hours. The molten batch is tapped into a settler from which the slag overflows into pots. The molten tin from the bottom of the settler is cast into blocks of one to two tonnes and the cooled slag, which contains tantalum, is crushed and re-smelted in the secondary furnace. The resultant tantalite 'glass' is then ready for export.
- Tin produced by smelting contains metallic impurities that must be removed by refining before the tin is marketed. The tin blocks are upgraded by heating to a temperature of about 750°C. Metallic impurities form a dross on top of the molten tin metal that is skimmed off. Finally, the tin is cast into 17kg ingots for sale or export.



● Major tin and tantalum deposits in W.A.



1957 - 1963

Production in the Pilbara and Greenbushes was re-established due to higher tin prices, and the availability of improved earth moving equipment.

1960

Tantalum first used in metal joint replacements.

1986

The world tin price collapses forcing closure of tin mines world-wide.

1998

Production is now based on open pit mining of primary pegmatites at Greenbushes and Wodgina, primarily for tantalum.

TIN & TANTALUM FACTS



The word **tin** is Anglo-Saxon in origin, but the symbol **Sn** comes from the Latin 'stannum' that actually refers to the properties of an alloy of silver and lead.

Tin exists in **two allotropic forms**, grey or alpha tin (below 13.2°C) and white or beta tin (above 13.2°C)



Tin is a **soft silvery-white** metallic element which is **ductile** and **malleable**. It has a **low melting point** of 231.85°C

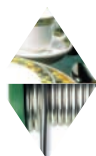
Due to its **high resistance to corrosion and fatigue**, tin's major use is for tin-plating (coating low-carbon steel with a thin coating of tin), used for food packaging. The coating also improves the metal's workability and ease of soldering.

Tin is **non-toxic** and **easy to recycle**.



Inorganic compounds of tin are used in ceramics, glazes and as a reductant and fixing agent in textile dyeing.

Organic compounds of tin are used in wood preservatives, fire retardants, pesticides and plastics as a UV stabiliser (such as PVC).



Tin **alloys** easily with other metals, and is used in alloys such as soft solders (Sn, Pb), bronzes (Cu, Sn) and pewter (>90%Sn, <10%Sb, Cu, Pb). Solder alloys account for one third of world tin consumption.

The name **tantalum** and symbol **Ta** come from the Greek 'Tantalos', a mythological king of ancient western Turkey. For his crimes, Tantalos was punished in Hades where he stands in water up to his chin and is 'tantalised' with food and water that moves out of his reach whenever he tries to satisfy his hunger and thirst. Tantalum was so called because of the tantalizing problem of its isolation from niobium, which took place nearly 50 years from its first discovery.



Tantalum is a **grey, heavy** metal with a **density** of 16.6 g/cm³, very close to gold.

When pure, it is **ductile** and can be drawn into a fine wire, which is used as a filament for electric lights and special research purposes.

Because of its very **high melting point** (2 850°C), tantalum is alloyed with cobalt, iron and nickel for use in the aerospace industry in jet engines and gas turbine parts.



The special **electrical properties** of tantalum make it useful for reliable electronic capacitors, such as in mobile phones, accounting for 50% of its use worldwide.

Tantalum has a **high resistance to corrosion** and is used in alloys, especially for the chemical industries, and for surgical appliances and implants because of its unreactive nature with bodily fluids and tissues.



Western Australia is the largest producer of tantalum in the world.

TIN & TANTALUM STATISTICS

Total Quantity of Tin Produced in Western Australia

2003 - 653 tonnes valued at \$4,184,604
2002 - 763 tonnes valued at \$4,967,874

Total Quantity of Tantalum Produced in Western Australia

2003 - 973 tonnes (tantalite)
2002 - 985 tonnes (tantalite)

2001 - 806 tonnes (tantalite) valued at \$179,338,155

Tin Royalty Receipts

2003 - \$122,823
2002 - \$130,818

Tantalum Royalty Receipts

2003 - \$5,486,403
2002 - \$4,992,273

Employment

In 2003, the tin and tantalum industry directly employed 450 people.

Primary Tin & Tantalum Producers in WA

SONS OF GWALIA LTD
Greenbushes, Wodgina.

Current statistics are available from the Statistics Digest on the Department of Industry and Resources website at www.doir.wa.gov.au

MORE INFORMATION

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July 2004

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ISSN: 1328-6838